Thin Client Performance for Remote 3-D Image Display

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Abstract

Several trends in biomedical computing are converging in a way that will require new approaches to telehealth image display. Image viewing is becoming an "anytime, anywhere" activity. In addition, organizations are beginning to recognize that healthcare providers are highly mobile and optimal care requires providing information wherever the provider and patient are. Thin-client computing is one way to support image viewing this complex environment. However little is known about the behavior of thin client systems in supporting image transfer in modern heterogeneous networks. Our results show that using thin-clients can deliver acceptable performance over conditions commonly seen in wireless networks if newer protocols optimized for these conditions are used.

Background

A thin-client computing system consists of a server and a client that communicate over a network using a remote display protocol. Using the remote display protocol, the client transmits user input to the server, and the server returns screen updates of the user interface of the applications from the server to the client. Examples of popular thin-client platforms include Citrix MetaFrame [1] and X11 [2]. The remote server typically runs a standard server operating system and is used for executing all application logic. Because all application processing is done on the server, the client only needs to be able to display and manipulate the user interface. While much work has been done to demonstrate the cost-effectiveness of thin-client computing to deliver computational services over Local Area Networks (LANs), little work has been done to evaluate the effectiveness of thin-client computing over wireless, Wide-Area Networks (WANs), or with the growing class of graphics and multimedia-oriented applications being used in health care.

Methods

We employed slow-motion benchmarking [3], to evaluate thin client performance. This method employs two techniques to obtain accurate measurements: monitoring client-side network activity and using slow-motion versions of application benchmarks. For the purposes of evaluating the performance of sequentially displaying slices using thin clients, we used an 85 slice, 128x128x24bit SPECT imaging of the liver. We compared the performance of X, Citrix Metaframe (ICA protocol), and our experimental protocol known as thinc [4]. All platforms were tested at 24bits per pixel to prevent any loss in visual fidelity, and 24fps video speed. The platforms were compared in their performance across various network bandwidths and latencies that might be seen in wireless networks.

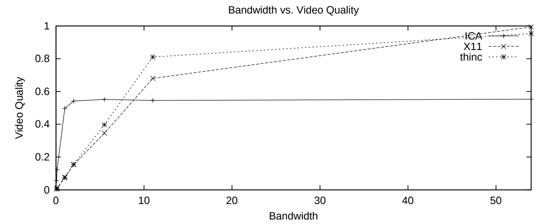

Figure 1: Effect of Bandwidth

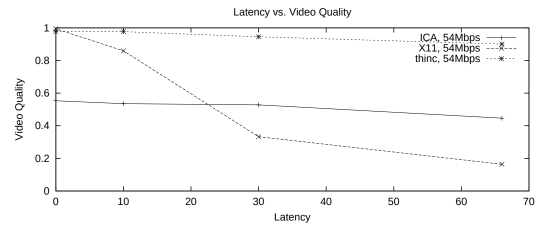

Figure 2: Effect of Latency

Results

The ICA protocol, which includes compression, performs best at low bandwidth, but does not use all available bandwidth. Both X11 and thinc perform better at high bandwidth (see Fig. 1). In evaluations of the effect of latency in a high-bandwidth environment, the ICA protocol shows moderate performance throughout the latency range. The X protocol is markedly affected by increased latency, while the thinc protocol (which is optimized for high-bandwidth, high-latency environments) performs significantly better (see Fig. 2). Thin clients are a practical approach to image review on high performance networks.

Discussion

Our measurements show that bandwidth availability is not always the main performance limitation and that designing for latency may be more appropriate. In addition, we show that thin-clients are a viable model for the delivery of 3-D medical data over wireless networks when using protocols designed for a high bandwidth, high latency, WAN architecture such as thinc.

References

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